



Super Hard Steel Supersonic Particle Deposition

Presented by:

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*Replacement of Hard Chrome Plating
Program Review Meeting*

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Kennedy Space Center Visitors Center

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INEEL Super Hard Steel

Developed at the Department of Energy's Idaho National Engineering and Environmental Laboratory (INEEL)

- Material forms a Metallic Glass or Nano Composite Microstructure
- Low Cost - No Exotic Elements - Uses Conventional Spray Methods

- **Composition wt%:** C-1,Mn-2,Si-1.4,Cr-20,Mo-5,W-6
- **Microstructure:** Amorphous or Nano Crystalline
- **Uses:** Wear, Corrosion and Impact Resistance



Technical Data

Hardness

as-HVOF sprayed
heat treated

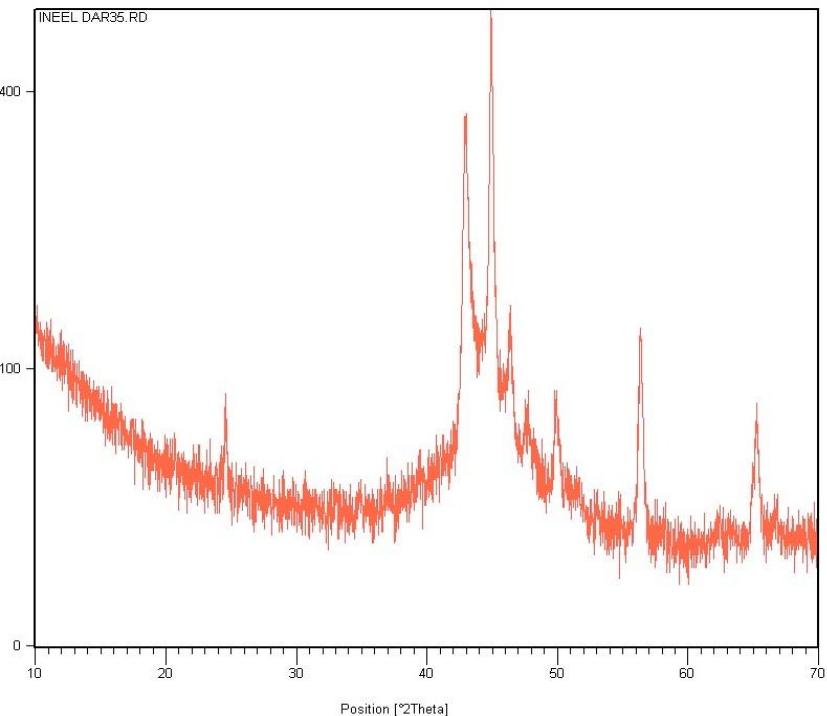
Vickers (300g)

1034
1364

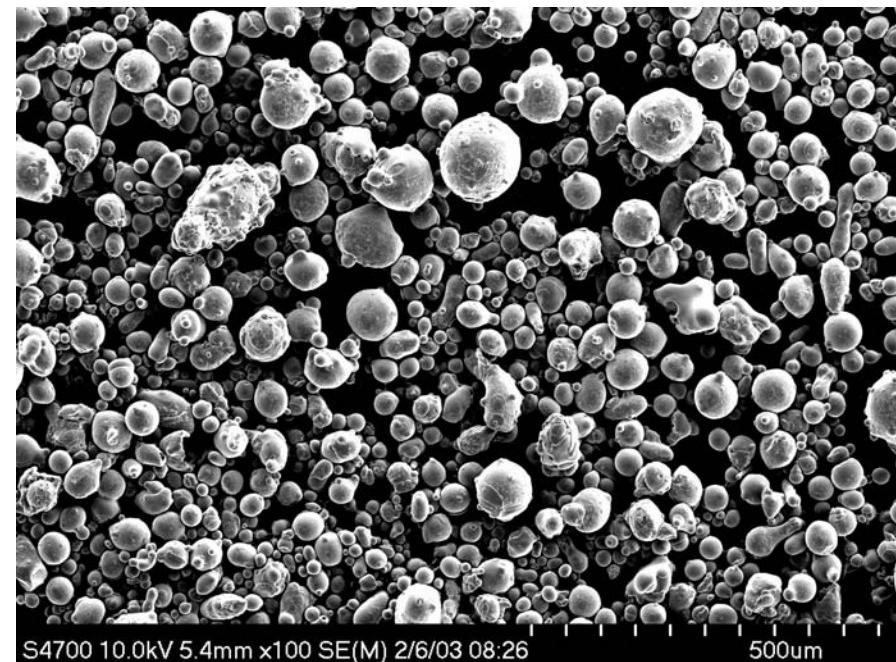
Rockwell C (Conversion)

69.4
73.5

Counts



XRD Pattern DAR 35 Powder



DAR 35 Powder FSEM



Processing Approaches

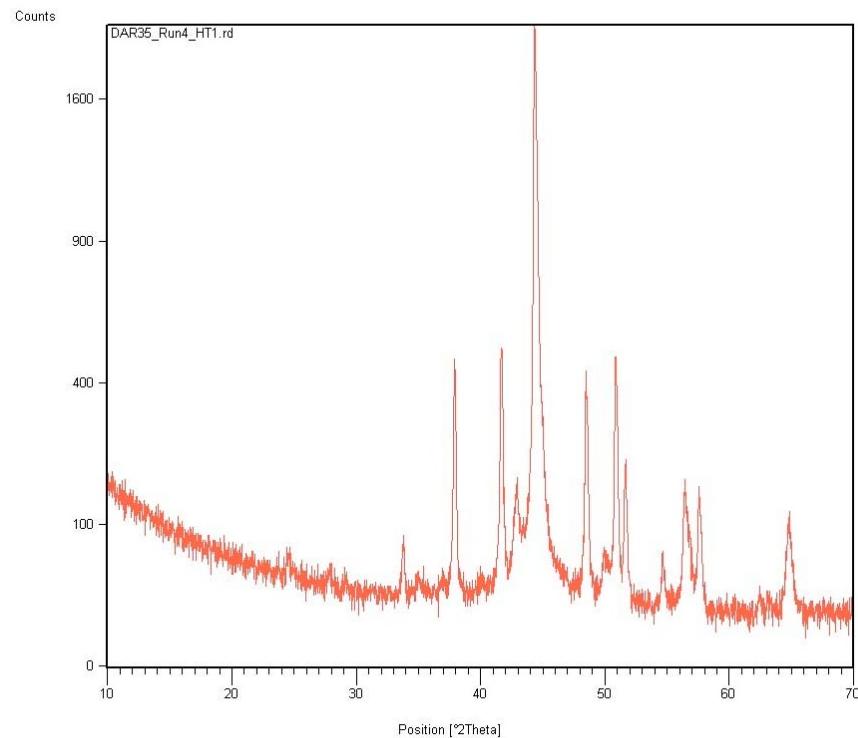
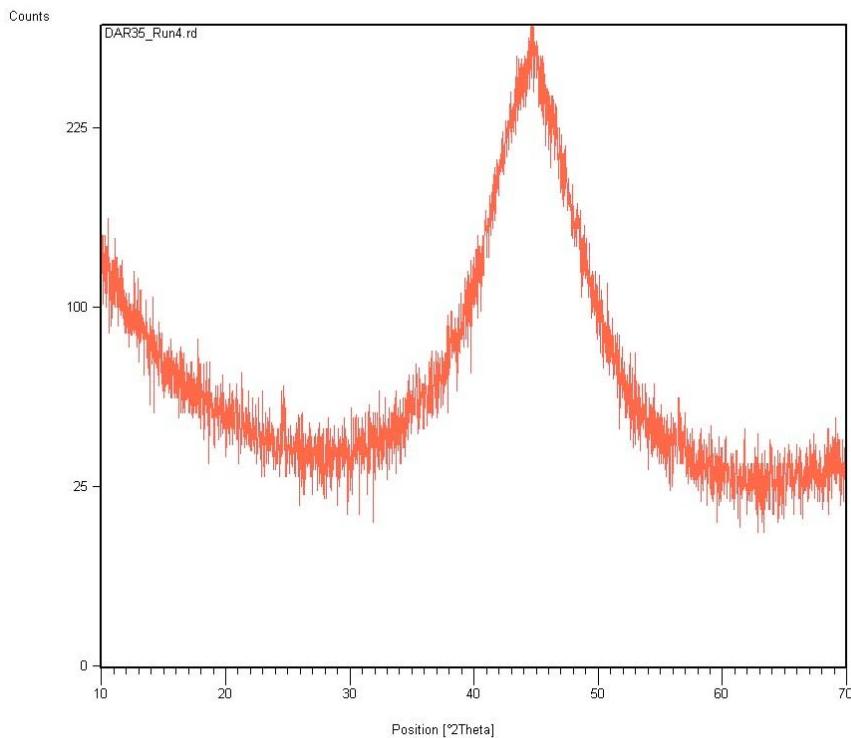


- HVOF
- Plasma Arc Spray
- Cold Spray
- Spray Forming

Maintain Armorphous and/or Nanocrystalline Structure



Accomplishments Utilizing HVOF Technology



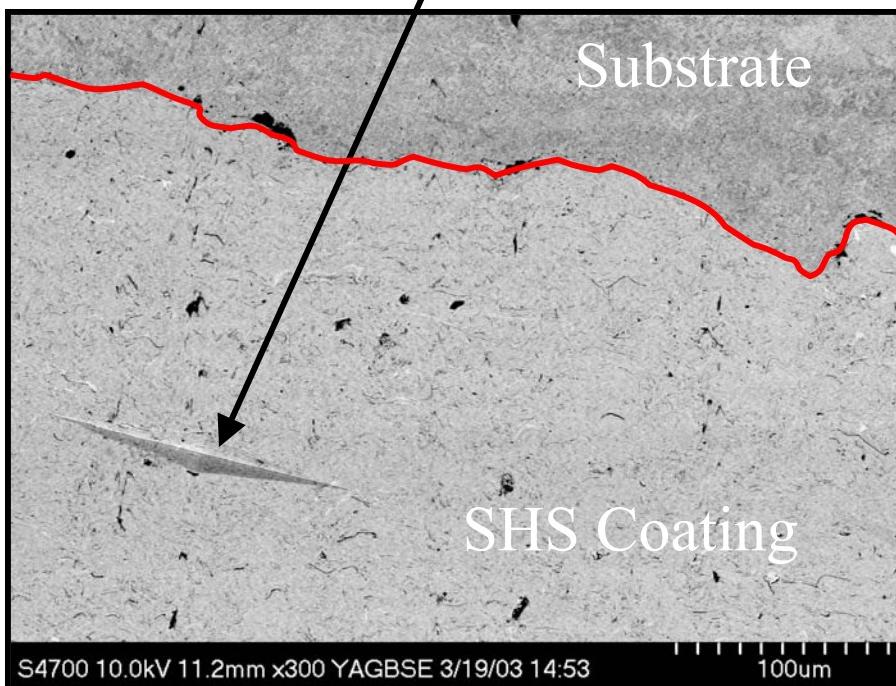
**XRD Pattern HVOF Diamond Jet
Amorphous Microstructure**

**XRD Pattern HVOF After Heat Treat
700° C for 10 min. Nanocrystalline**



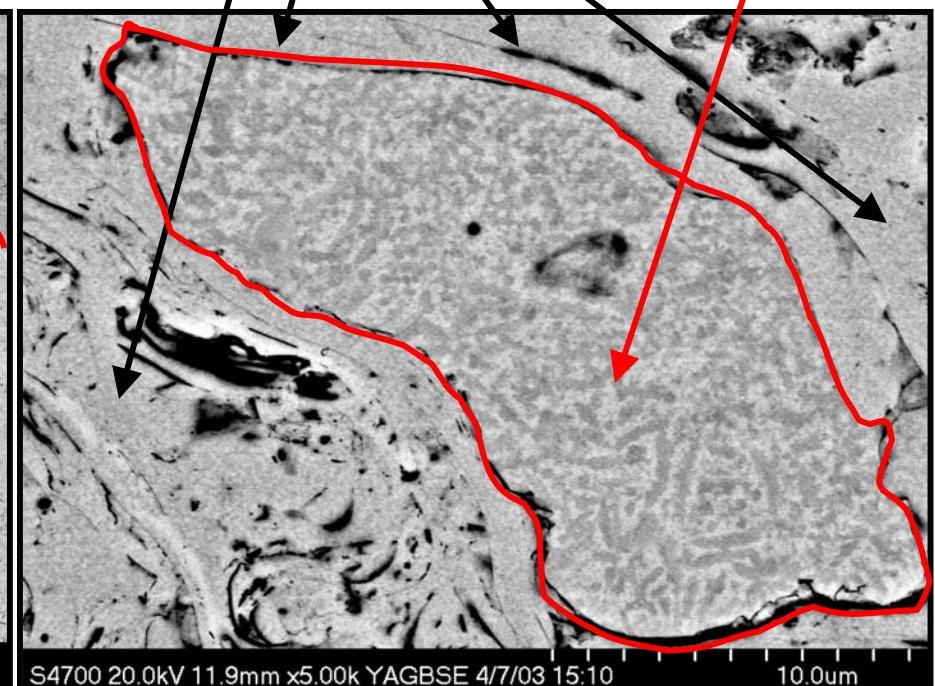
Microstructural Analysis of HVOF Coating

Hardness Indent



Amorphous

Nanocrystalline



HVOF As-Sprayed Microstructure

Microstructure After Heat Treatment



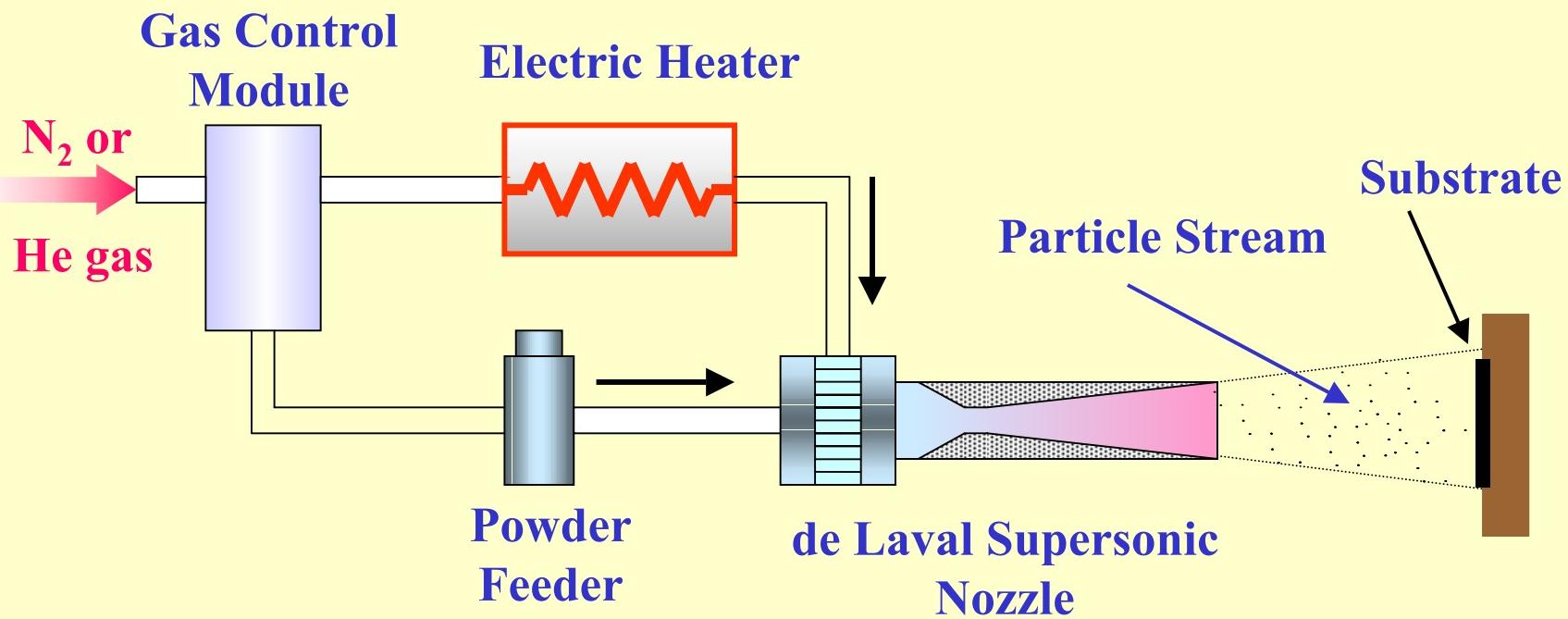
Supersonic Particle Deposition

•ARL -WMRD is the only facility within DOD and one of only a few entities in the USA to have a fully operational SPD System.

Main Gas Stagnation Pressure 100-500 psi Gas Temperature 0-1300°F Main Gas Flow Rate 30-100 CFM

Powder Feed Rate 10 to 30 pounds/hour

Particle Velocity 300-1500 m/sec.



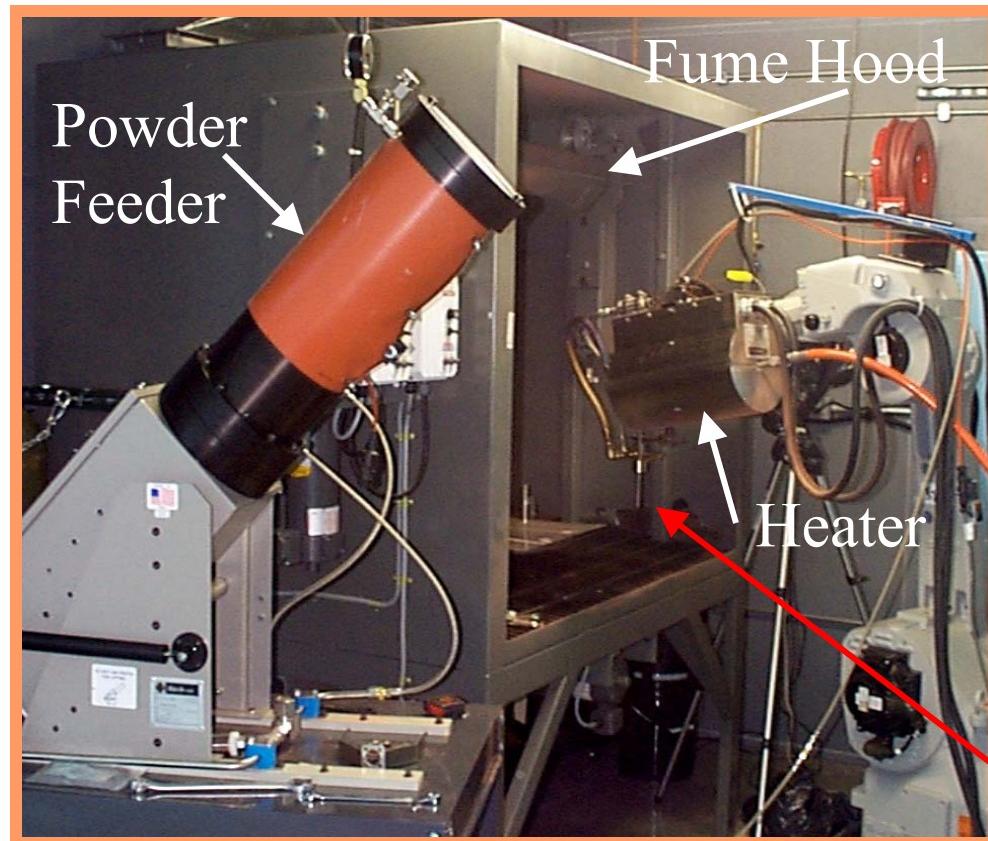


Cold Spray Advantages

- **High deposition rates**
- **Deposition efficiency greater than 70%**
- **Porosity less than 1%**
- **Low temperature deposition**
- **Solid state bonding**
- **High density, low oxide content**
- **Young's modulus 85% of bulk material**
- **High thermal & electrical conductivity**
- **Electrical conductivity near bulk material values**
- **Low residual stress**
- **Compressive residual stress**
- **Produces free-standing structures**



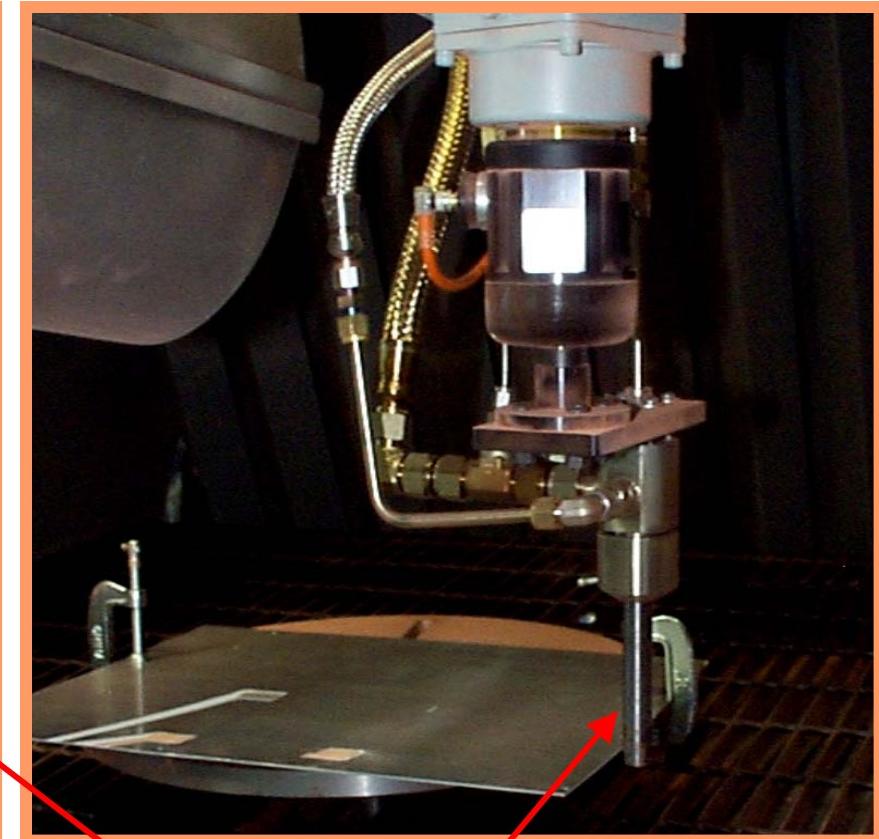
ARL SPD System



Powder
Feeder

Fume Hood

Heater

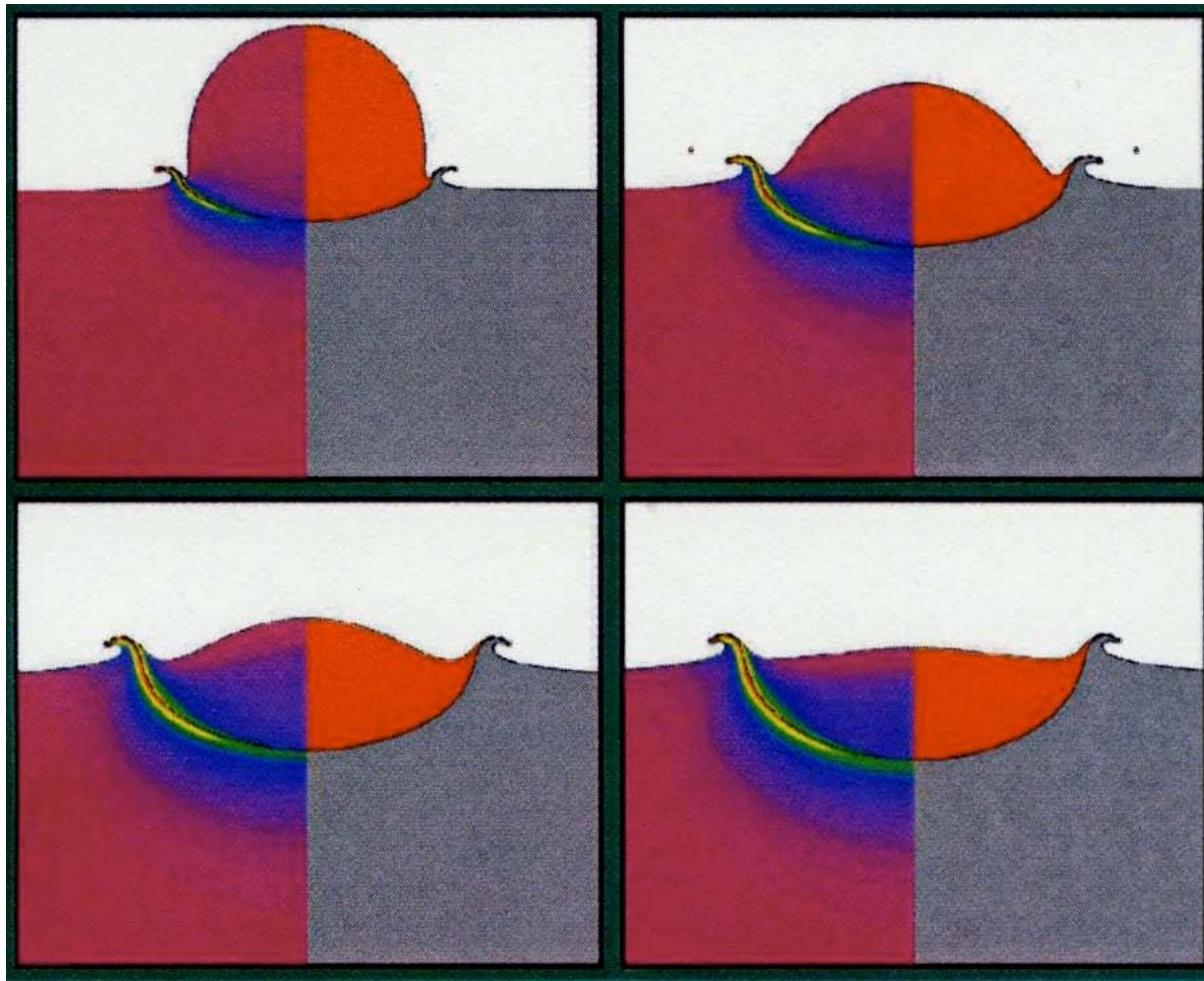


Robotically Controlled

Spray Nozzle



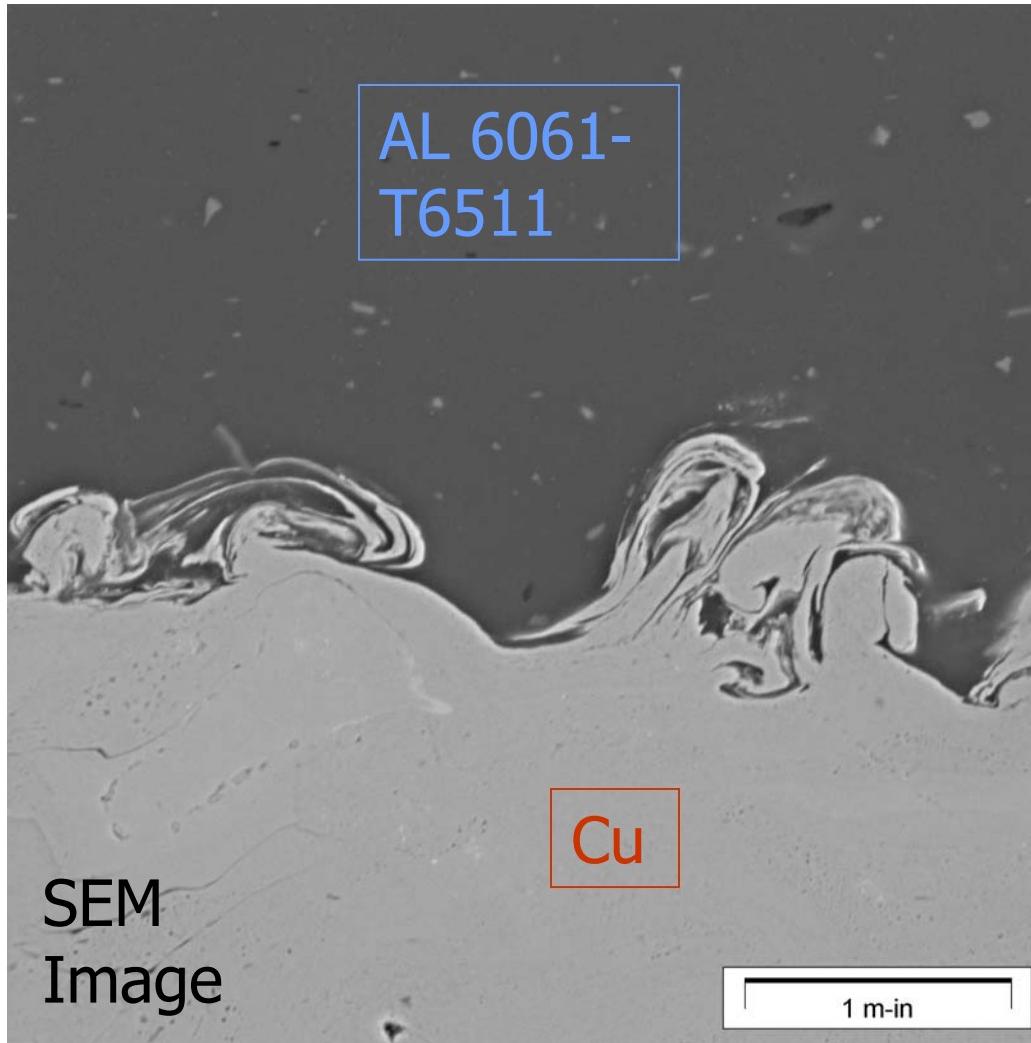
Particle Impact



From Dykhuizen et al, J. Thermal Spray Tech, Dec 1999.

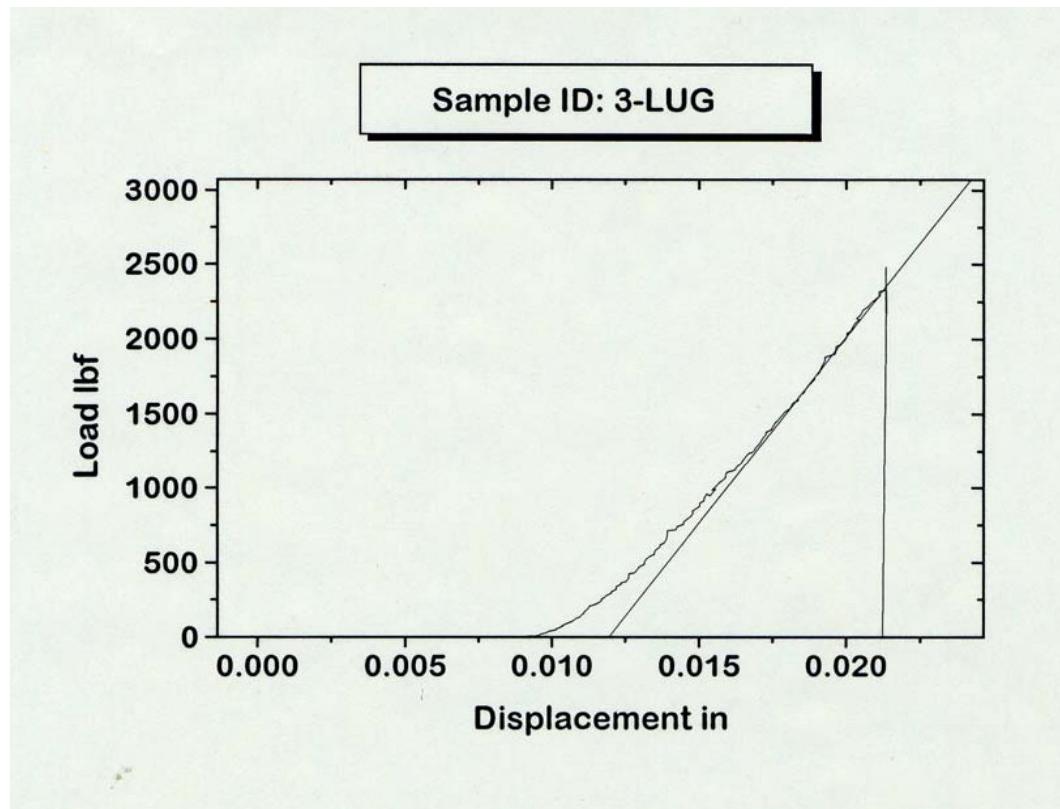


Copper Deposition on Aluminum





Copper on Aluminum



Shear Test Bond Strength = 11,650 psi



Typical Process Parameters

Carrier Gas

Gas Pressure

Temperature

Standoff

Traverse Speed

Powder Size

Powder Feed Rate

Nitrogen

300-400 PSI

400-450 °C

25 mm

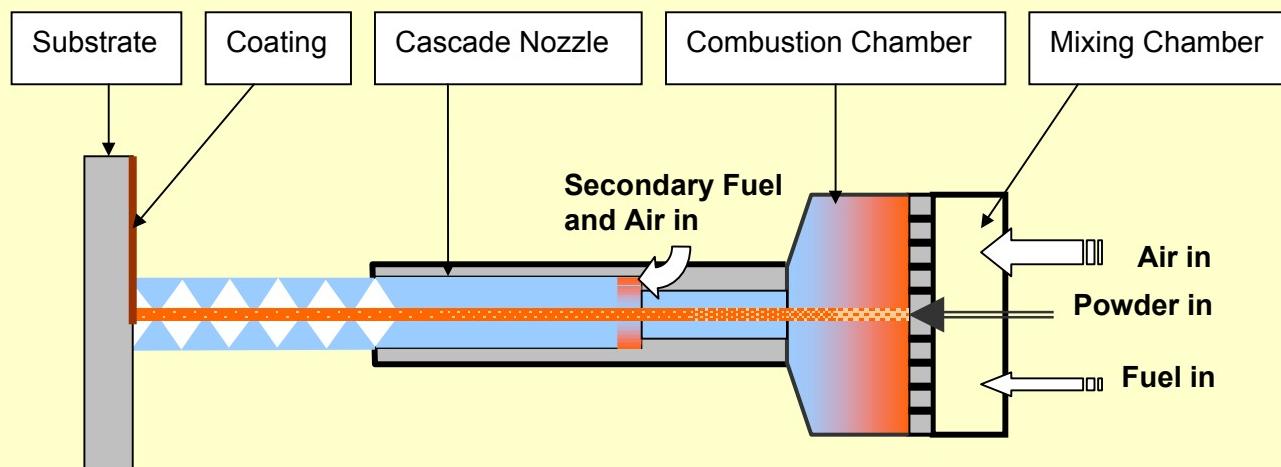
100mm/sec

5-45 microns

20-40 g/min



HVAF Gun Assembly





Benefits of HVAF

- Expands metal, alloy and carbide coating capability while retaining benefits of Cold Spray
 - High Productivity Rate and Increased Coating Thickness
 - Low Porosity, Non-Oxidized Coatings
 - Coatings are essentially free of residual stresses